Arguments for Contextual Teaching with Learning Fields in Vocational IT Schools – Results of an Interview Study among IT and CS Training Companies

Simone Opel
Didactics of Informatics
University of Duisburg-Essen
Schützenbahn 70
45127 Essen, Germany
simone.opel@uni-due.de

Torsten Brinda
Didactics of Informatics
University of Duisburg-Essen
Schützenbahn 70
45127 Essen, Germany
torsten.brinda@uni-due.de

ABSTRACT

Professional IT education and training in Germany consists primarily of two parts: students attend part-time vocational school and work as apprentices and employees at their training companies. To promote learning venue cooperation between the partners of vocational education, the curricula in the fields of computer science (CS) and information and communication technologies (IT) are arranged in so-called "Lernfelder" (learning fields), which are supposed to be put into practice by using learning situations. These learning fields are based on real-life working processes and allow contextual learning. However, teachers are not putting this idea into practice; one reason for their non-adoption of the concept is a lack of appropriate teaching material. The interview study of this paper explores the apprentices' IT/CS-related working processes and environments in various selected training companies. Its results were used to correlate the curriculum's aims with the covered occupational working processes. This is an incremental step of a larger project which targets the development of exemplary learning situations and helpful tools for several learning fields to support teachers in creating lessons for vocational IT and CS training.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education—*Computer Science Education, Curriculum, Information Systems Education*

General Terms

Human Factors, Theory

Keywords

Vocational IT Education, Computer Science Education, Learning Fields, Learning Situations, Empirical Study, Interview Study, IT Company Training, CS Company Training, Learning venue cooperation

WiPSCE '13, November 11–13, 2013, Aarhus, Denmark

1. INTRODUCTION

1.1 Vocational IT/CS Education in Germany

Attending vocational schools instead of universities is a well-established way to professional life in Germany and follows the idea of "Berufskonzept", or the "vocational principle" [4]. Students who attended general or intermediate secondary schools ("Hauptschule/Regelschule" or "Realschule") usually take up training and education at companies and part-time vocational schools[1] (so-called "Duale Berufsausbildung" – dual vocational education and training) for two or up to three years (depending on the chosen occupation). There are different models of school attendance; one model is attending classes one day per week, but especially in the field of IT/CS there are usually full-time classes for one or two weeks, followed by two or up to four weeks of training on the job. Students are apprentices and employees of their training company during the complete apprenticeship.

The students leave their formal apprenticeship as skilled workers, e. g. as IT specialists; this is one difference to a university study: university students (who attended an upper secondary school called "Gymnasium") leave with the academic degree of Bachelor or Master, e.g. as computer scientist, and only take part in internships at several companies during their studies, but they are neither apprentices nor employees of any company.

Another difference between vocational school education and university studies can be found in the objective of the apprenticeships. At universities, students acquire a deep knowledge of the theory of the subject. To lead the apprenticeship to success, vocational students should gain the ability to connect theoretical knowledge taught at vocational school with the individual working experience. To reach that objectivw, there are different models of cooperation between training companies and vocational schools. What all models have in common are interdisciplinary learning arrangements and cooperation between vocational training and school [3] [22] [10].

[1]In this paper "vocational school" means only schools for dual vocational education and training; full-time vocational schools are explicitly not included.

In contrast to vocational education in some other countries, vocational training companies and the official trainers in Germany are regularly monitored by the chamber of industry and commerce or trade. The companies use official frameworks for apprenticeships and they are involved in the final examination of their apprentices[2]. The certified trainers have to attend specialized pedagogical courses (with a final examination from the chamber of industry and commerce) before they may provide instruction to any apprentices. So it can be assumed that the companies' certified trainers are qualified to report about the training conditions of their apprentices, the competencies which are considered important for the respective profession, and essential IT/CS working processes of their company.

1.2 Characteristics of Vocational IT/CS Curricula

As described above, vocational schools and training companies should work hand in hand. The apprentices[3] have to learn the theoretical background of their profession, but they must train their abilities to solve specific problems of their job as well. As a consequence the lessons at school should impart general and occupational education, which should be taught by using activity-oriented forms of teaching [25].

Another challenge is the request for interdisciplinary collaborative teaching and learning during the students' lessons. Working on interdisciplinary projects helps the students improve their problem-solving abilities [24], a valuable competence for all occupations, not only in Germany but many other countries [11] [23]. To support teachers in developing contextualized and activity-oriented lessons, the learning content in the curriculum is arranged in learning fields, which are suitable for implementing activity-oriented learning situations.

What is the difference between a learning field and a learning situation? Learning fields as part of the obligatory curriculum are topical units which contain didactically reduced business and working processes. The description of a learning field does not include specific aims to be reached or skills to be acquired, but it describes different competencies which students should gain. By alternating multidisciplinary theoretical and practical training, students should acquire the competencies to apply their skills in new professional situations [25].

Learning fields are developed by didactically reflecting and reconstructing typical business and working processes [1]. The resulting definition should include theoretical and professional skills from different former subjects supplemented by different social and personal competencies (see fig. 1). The description of a learning field consists of two different parts: the section "aims" describes all skills and competencies, which should be gained by the students. The section "content" describes the theoretical topics and knowledge in a very common way. The subsequent curriculum consists of several learning fields and contains all skills and competencies the students should gain during their training.

The transfer from learning fields to suitable learning situations is part of the teachers' work. A learning situation contains one single working process, which has been didactically reduced. The teachers have the leeway to develop learning situations depending on their spatial, personal and social conditions; they only have to ensure that the chosen learning situations will enable the students to gain all competencies described in the curriculum.

Learning field *(first year, 60 lessons)*
Application development and programming

Aims:
The students are capable to analyse, design, implement and programme complex application systems. They design didactically reduced applications methodically and appropriately. They reflect on their approach and provide aspects of quality assurance. They apply methods of software development and implement applications based on known algorithms and data structures by using software development tools. They are enabled to reflect their strategies.

Content:
Development of application systems
- Model of project management
- Development strategies and action models for software engineering
- Methods and procedures of quality assurance
- Methods of actual analysis of business processes and IT systems
- Methods and tools for developing solution concepts and documentation

Methods of programme development
- Basic algorithms and data structures
- Structuring and documentation

Figure 1: Example for the definition of a learning field [25]; in German, translation by the authors

To clarify this concept, we explore the learning field "*application development and programming*" (see fig. 1) from the first year of training. It demands that "[students] apply methods of software development and implement applications based on *known algorithms and data structures* by using software development tools" [25]. This description of the demanded competencies has to be put into several learning situations by the teachers. So a team of teachers has to develop different teaching sequences which build upon another. Each teaching sequence is comprised of at least one aspect of a working process at a company. A basic module to teach sorting algorithms (as an example for known algorithms) could consist of the implementation of a given part to sort data from a larger software project. The teacher presents the whole project to the students, afterwards the teacher focuses on the part of the project, which will be realised, and teaches the theoretical knowledge which the students need to solve the problem. If it is possible and valuable, teachers from other learning fields could add some aspects to the topic of the learning situation. Although the students only implement a part of the project, they should bear in mind the complete process of software development. Teachers have to consider the fact that each learning situation contains theoretical knowledge, several working skills and different competencies to solve complex problems.

For this reason, the preparation time needed to develop a balanced learning situation, which includes different aspects of the topic [5], is one factor of concern for the teachers. According to the teachers it would take much more time to prepare and provide balanced and interdisciplinary learning situations with mixed teaching methods than to teach in a traditional teacher-centered way with simple stand-alone examples. Therefore the teachers of many schools do not put the concept into practice [18] [12]. But one part of the concept is to enable teaching in teams [2], so teachers from different disciplines can share the workload and support each other.

Another aspect is the motivation of the teachers. Ni [17]

[2]All apprentices have to pass a final examination from the chamber of industry and commerce at the end of the apprenticeship.

[3]In this paper, students and apprentices are used synonymously; "student" is used from the school's perspective, "apprentice" is used from the company's view.

found that motivated teachers, who in addition pay attention to research results, external materials and methods, are more willing to put a new concept into practise. For this reason it seems to be valuable to support these motivated teachers by presenting them with ideas and materials to help creating learning situations on their own.

At the moment, teachers only have materials and textbooks about theoretical topics in CS or IT, but they often have no idea how to create a suitable, motivating and practical learning situation [19] [18], and how to connect these learning situations to the apprenticeship at the company. For this reason it is necessary to develop guidelines on how to deal with a curriculum which consists of the description of competencies, and how to bring the aims of vocational schools, training companies and students together. One further step to that goal is to explore in detail basic working processes as a source of inspiration in the field of IT and CS.

This presented us with our research questions: what could typical working processes in the field of IT/CS for an IT specialist? How are the apprentices integrated into these processes be? Where are the links between vocational schools and training companies?

Although there are a lot of job descriptions in job advertisements or outlines of several CS/IT professions, we are looking for specific and individual working processes and not for abstract key words given in general job descriptions.

The resulting working processes will be used as a basis for the development of teaching materials and guidelines, which should support teachers in creating learning situations on their own. Another aspect we considered is whether the typical teaching contents cover typical working processes and vice versa. This information will help us to evaluate different ideas for learning situations, and to select important topics from the fields of IT and CS.

1.3 Related Work

Our research affects different areas. One area revolves around teaching methods and principles.

The concept of learning fields demands that lessons should be presented by using activity-oriented forms of teaching and examination. This idea can also be found in the constructivist concept of "contextualised teaching" [15] (IniK – "Informatik im Kontext" – "computer science in context") which has been developed for secondary schools. This concept should bring students into contact with different aspects of a given problem from the fields of IT or CS, which are situated in their own environment and life. The chosen context should rouse the students' interest for computer science and should enable them to get a broader view of the topic, not only from the view of computer science. The IniK concept has been created to teach general knowledge.

The context should be interesting for the students' daily life. Examples for contexts are "cyberbullying", "file sharing" or "dealing with social networks" (interdisciplinary module), but also topics like "chatbots" [26] [27] or the principles of cryptography in context of "Email for you (only?)" [7].

This idea is related to the concept of learning fields, which also contain different aspects of one special problem. Although the ideas are similar, there are several different goals and preconditions. The most important difference is that a learning situation is always used to teach occupational knowledge and skills.

Because of this all learning situations have to be related to working processes in the field of IT/CS, the context "cyberbullying" is not applicable as a learning situation, but the module "chatbots" from IniK could be adapted to companies' working processes, which could be an interesting job.

The importance of choosing a useful context is also described by Kolikant and Ben-Ari [14]. They relate that students and teachers would have different perspectives on the same topic. The authors name that phenomenon "culture clash" and recommend that teachers should make professional practices accessible by using helpful and practical contexts, tools and methods.

Huggins [8] describes the concept of cooperative education as a method, which combines lessons at school with practical work experience. Students can learn the most relevant principles of their discipline, they see the relevance of different topics of computer science and they can develop something valuable for the educational partners (mostly companies). This idea is close to the German concept of dual vocational education and training. Huggins does not present new aspects from our point of view, but he confirms that alternately teaching theoretical knowledge and practising at the company has a lot of advantages for all partners, not only for the respective students.

Another area to be explored is the cooperation between the different partners in the field of IT/CS education. But we did not find any research projects that focused on different aspects of the relationship between vocational school and training company and included all partners of the cooperation in the field of IT/CS education.

For example, the study of Pilz [20] focuses on general differences in vocational education in Germany and Britain. While the expectations of the companies regarding the benefits of the training seem to be similar ("The main benefit is equipping workers with skills and competencies, a benefit mentioned by all British and German respondents on the grounds that skilled workers will perform well" [20], p. 65), there are big differences concerning the influence of national philosophy on education and training or the labour market.

Another study by Ryan [21] explores the practices and objectives of vocationalism and concludes that it could be most favourable to connect postcompulsory programmes with general educational content. This idea seems to be similar to the German vocational schools' curricula, which connect professional knowledge and general education.

To explore the advantages/disadvantages and the success of different vocational transition systems like "education logic" and "employment logic", Iannelli and Raffe [9] evaluated data from different national school leavers' surveys. They found that vocational effects seem to be stronger in systems and countries with strong linkage between labour market and secondary schools. These systems tend also to have more standardised education systems comparable with the German vocational school system.

The study of Fuller et al. [6] explored professional values which the companies expect from young academics. The named attitudes and behaviours (honesty, loyalty to organizations, openness to constructive critique, personal commitment to quality etc.) are not surprising and new, but could also be useful for skilled IT specialists.

All these studies confirm that it is valuable to research further aspects of the vocational IT education in Germany, but they cannot answer our questions.

2. METHODOLOGY

In 2012 we conducted semi-structured guideline interviews with certified trainers of eight IT/CS training companies. The selected companies were recommended by teachers, the chamber of industry and commerce or were well-known in public for their excellent work or their well-educated employees. To cover as many occupational aspects as possible, the companies have completely different profiles and sizes. All companies have in common that they provide at least training for "Fachinformatiker" (IT specialist for system integration or application development) or "IT-System-Elektroniker" (IT system electronic technician).

The companies partaking were:

- One *automotive part supplier* (abbreviated as APS; used for clarifying results) with 19,000 employees in more than 20 countries. It is training company for about 250 apprentices, eight of whom are IT specialists for application development.
- One *insurance company* (IC) with 9,000 employees. There are ten apprentices in each year of training, all together 30 apprentices in the field of IT specialists. This interview was conducted with the certified trainer for IT/CS and two IT specialists and former apprentices, who were very experienced in all topics concerning apprenticeship and vocational school education.
- One *telecommunication company* (TC) with more than 70,000 employees and around 9,000 apprentices in Germany, which offers apprenticeship in different professions in the field of IT.
- One *university data-processing centre* (UDC) with around 150 employees and ten apprentices as IT specialists for system integration. It is service provider for the whole university with about 12,000 employees and 35,000 students in different departments and locations.
- One *IT system house* (ISH) with 70 employees and two apprentices as IT specialist. The system house offers all types of IT services, but also application development and consulting for several ERP systems.
- One local *internet service provider* (ISP), which offers access to its own fibre optic broadband network, IT services and an internet radio station. The company employs around 30 persons, one of them as apprentice as an IT specialist for system integration.
- One *manufacturer of optical devices* (MOD), with around 100 employees, who produce, sell and dispatch different optical devices and technical ceramics. The factory employs one apprentice as an IT specialist for system integration.
- One *building authority* (BA; around 300 employees at 12 locations), whose IT staff supports the departments by offering all types of IT services and user support.

Each interview took about one hour and was voice recorded. The recordings were transcribed and summarised. After that we evaluated them by using methods of content analysis by Mayring [16]. The deductive categories were directly derived from the interview guidelines. While evaluating the interviews, additional inductive categories were added, following a grounded theory model.

The interview guideline consisted of four groups of topics.

- In the first part we asked for statistical data and common information about the company, as given above.
- The second topic revolved around the training at the company.
  Keywords were organisation of the training, essential facts during the apprenticeship, important working processes and everyday work of the company's IT employees or trainees' involvement into these processes.
- The third group asked for skills and competencies.
  We asked for the skills and competencies which were expected to exist beforehand as well as those which the apprentices should gain during their training.
- The fourth part affected the cooperation between training company and vocational school.
  Keywords were mutual support or expectation towards vocational schools and their lessons.

One characteristic of semi-structured interviews is that there is not a defined set of questions, but a framework of topics to talk about. The interview guideline has no strict order of the questions, but it lists informally the important aspects or questions. That is the reason, why we could not include a complete interview guideline.

3. RESULTS

3.1 Organisation of Training

Regarding the results on the organisation of the training, it is suitable to group the answers according to the number of trainees a company employs, as results do not depend on the profession or the profile of the company, but only on the number of apprentices.

Companies with only one or two apprentices (ISH, MOD, BA, ISP) reported that their trainees would get some basic introduction in important working methods, software and business processes. After that they would learn directly by working on the job. They had to master several tasks and parts of projects, whose complexity would grow during the training. But no schedule existed specifying which competence would be trained in which period of training. So which competence would be gained would happen by chance and by the certified trainer's experience. The trainers related that they would not explicitly train personal, methodical or social competencies like communication skills, teamwork, search techniques, or documenting work. All these methods were trained implicitly during the everyday work. The apprentices would become specialists in the whole company's IT and CS tasks, but they would not be highly specialised in one certain task.

Companies with more apprentices (TC, UDC, APS, IC) used detailed schedules specifying which apprentice would work at which department of the company during which period of time. The exact cycles varied, they lasted between one week and several months. All trainers reported that during the first weeks, the apprentices were assigned courses about using different software, and they were trained in presentation skills and different working methods. After

that apprentices started working in different departments, in most companies (TC, APS, IC) in pairs. The tasks they were assigned depending on their previous knowledge and their current period of training, in the late second and third year also on their interests. After each working period, the companies provided assessments of the trainees as well as the trainers. Depending on different fields, the apprentices received individualised training courses in IT (network technologies, configuration of servers or routers and deeper knowledge of operating systems) or CS (programming languages in different degrees, methods of software development e. g.). In the third year of training the apprentices carried out their examination project for the final examination, so they stayed in one department; this was usually the department they finally stayed in after finishing their training.

One common result shows the more apprentices a company has, the more formal and reproducible the training has been designed. Nevertheless, the level of structure is not a sign for quality of education, as also companies with only one apprentice and less structured training have very well-educated apprentices.

3.2 Reported Working Processes

During an interview of about one hour, we got many details about the individual working processes. This information gives us a deeper insight into the daily work as any job description can do that. For general evaluation, we tried to summarise the given information about the working processes in a few sentences each. In the next step we summarised similar working processes from the different companies. The working processes described below are result of this summarization.

The concept of learning fields also includes interdisciplinary projects and working processes. It is interesting that the trainers of the university data processing centre and of the building authority reported that there are only technical processes; even the purchase of hard- and software is no part of the apprenticeship. Both see themselves as service provider for all employees outside the IT department. So – except for technical skills – the most important competencies the apprentices have to gain is dealing with their clients and documenting their work.

Both trainers described the following business processes:

A new employee needs a working place. The employee and his superior order a computer with different specific software and equipment. The operating system and all required software has to be installed and configured according to company rules; the computer has to be integrated into the network. All work has to be documented. After that the computer and its periphery has to be installed at the employee's office. The new employee has to be introduced to working with this computer.

User help desk: A client has a problem with his computer. He contacts the IT support by telephone, mail or by personal visit. The IT employees have to decide whether they can help the client themselves or whether another company (e. g. in guarantee case) has to be involved. In both cases they have to start the respective working process. This scenario was described by other trainers (APS, MOD) as well.

New software versions are available and have to be installed on numerous computers. Therefore a plan for the roll-out has to be developed, especially if data has to be transferred or converted. All work has to be documented. In some cases the users have to be introduced to the new version.

Other mostly technical working processes from the field of IT were reported, too:

In particular the trainer of the data processing centre reported *installation, maintenance and support of servers* for different purposes, according to the company's guidelines and the users' needs, as an important working process. For these tasks the system administrator has to have the ability to quickly familiarise himself with new topics and to understand complex information, mostly in English.

The trainer of the building authority also reported routine and corrective *maintenance of their telephone system.*

The telecommunication company as well as the internet service provider described the installation and configuration of *telephone and broadband connections*, different installation services between subscriber and central office and at the access network.

Both also described *installation and support* of different kinds of customer IT solutions, including all hard- and software components.

The other companies' trainers declared that it would be very important for the apprentices to understand the company's workflow and the underlying business processes for their daily work. They also reported the following working processes in the field of IT and CS:

Modelling business processes by using IT infrastructure: the manufacturer of optical devices has modelled the whole business process from receiving an order to dispatching the delivery into its computer system. So the quality of user support depends on the IT specialist's quality of understanding the flow of information and goods.

A typical task was the adaptation of the computer system to a remodelled business process. This could have effects on the network and computers itself, but also on software and user interfaces. The trainer related that the introduction of new barcode labels and contracts with another parcel service lead to new processes; therefore they had to extend their ERP system, their database and the corresponding user forms to benefit from these optimised business processes. The apprentice was a full member of the project team, so he had the opportunity to gain much knowledge about completely different topics.

The assurance company also modelled its workflows into its computer system, so all IT working processes had to become attuned to these business processes.

One specific working process related by the trainer was *application development for the collection department or accounting department.* The IT specialists have to maintain all hard- and software. For managing new products they also have to modify or extend the ERP software. Since the apprentices had worked in different departments, they should be familiar with the company's fundamental business processes. The IT specialists should be able to develop the required software. During this work they have to determine the employees' needs and necessary interfaces or underlying data structures, they have to create detailed project plans and develop the software.

The example described above is similar to those reported by the automotive supplier and the IT system house. These trainers explained that they would take much care of creating project plans and concepts before starting to programme, because all steps have to be documented, also for proof towards their customer.

The trainers described different working processes an IT specialist has to be capable of performing: the first process contains all work of *planning, documenting and accounting an application development project*, the second process describes the *implementation of project plans into functional software*.

Especially the IT system house, which also develops modules for accounting and ERP software, emphasised diligent planning and testing because of the modules' influence to the customers' bookkeeping and accounting; IT specialists and apprentices as well, have to have deep knowledge about these topics. In the first periods the apprentices would start with small parts of a defined project, e. g. they would implement reports to existing modules under their trainers' supervision; later they were able to develop and test modules on their own. They would always get help by colleagues and trainers, but they had to ask.

Other working processes described by several trainers (ISP, TC, ISH) came from *customer advisory service*: A customer needs advice on how to optimise his ERP software, his IT system or his internet services. The IT specialist has to analyse the situation – technically and economically – and after that he has to recommend the best solution to the customer. He has to present and explain his recommendation to the customer in an adequate way. All analysis and recommendations have to be justified and documented. The apprentices are taught those skills in different ways; the telecommunication company uses specialised learning environments to prepare their apprentices for their jobs, the smaller companies teach the skills by immediate work on several projects.

3.3 Competencies and Apprenticeship

One part of the interviews was about the competencies the apprentices should bring along.

Surprisingly, all trainers were not expecting specific skills in IT or CS; only the IT system house called for basic knowledge of business economics. Three companies (UDC, IC, APS) preferred apprentices with a previous internship in IT/CS or with informatics at secondary school; the trainers supposed these young adults would know better what their vocational choice would involve.

The most frequently mentioned competencies and prerequisites were the ability to work independently, motivation and interest to learn (named six times each), the ability to work in teams and a friendly attitude towards colleagues and customers (named three times each).

In addition, the companies expected skills in English, mathematics and a general aptitude for verbal reasoning.

We also asked for problems arising in apprenticeships. Some trainers reported no general problems, but an increase of "unpunctuality" and "discourtesy" were named as well as a general lack of perseverance in dealing with difficult problems.

Another question dealt with the competencies the apprentices should gain during their training. Apart from IT/CS skills, the trainers tried to promote personal competencies and personal development. The big companies also explicitly supported development of methodical competencies, e. g. information research, writing documentation, and presentation skills. All trainers emphasised that the apprentices should develop and grow up.

3.4 The Role of Vocational IT/CS School Education

To promote learning venue cooperation between training company and vocational IT school, we asked about mutual support as well as for problems and expectations toward IT schools.

In general the trainers reported to be satisfied with the cooperation they experienced, but there were some aspects they would like to improve upon.

Some trainers held the opinion that subjects like German (grammar and literature), social studies or physical education were superfluous; but on the other hand all trainers expected the teachers to impart deep skills in documenting and presenting work.

Especially the companies with detailed training schedules would be interested in receiving more information from schools, e. g. the annual didactic planning to optimise their IT/CS training. They would also be interested in more information about their apprentices' individual skills and problems.

The first request could be easily fulfilled by strictly putting the concept of learning fields into practice. This concept demands a complete annual planning to ensure that the chosen learning situations cover all competencies which should be gained by the students. The second request is part of individual cooperation and has to be discussed directly with the responsible schools.

The companies perceive themselves as experts for their needs. They expect that basic IT and CS knowledge should be taught at school. The trainers held the opinion that because of the existing diversity between the companies, it would be of no importance which programming language or e. g. transmission protocol was taught. They expected that their apprentices understood the underlying IT/CS concepts, thus enabling them to transfer their knowledge to other problems and situations at the training company; in this way, the apprentices could become specialists in different IT or CS tasks.

As a consequence, teachers should develop learning situations which focus on different concepts and support a deeper understanding of the learning content. Teachers have to find balance between the newest technologies, which should exemplarily be presented, and basic competencies which students need to solve problems in their daily work.

A further aspect is the heterogeneity of the classes. The different goals and fields of activity of the companies increase this. It is up to the teachers to reduce the gap between students' knowledge by developing learning situations which advance all students.

Another point mentioned were the teaching methods used by the teachers. Without knowing the precise definition of the concept of learning fields, the trainers proposed to carry out more interdisciplinary projects to encourage the apprentices' working competencies. They wished that teachers would use more activity-oriented and self-organised learning methods; this exactly would mean putting the concept of learning fields into practice.

The assurance company's former apprentices also related during the interview that they felt the lack of encouragement in solving problems creatively, particularly in programming and software development. They would have preferred problem-oriented lessons instead of teacher-oriented instructions. It is well known that especially for software development a

huge amount of creativity is needed [13], and for that reason it would be useful to encourage the students to improve upon these competencies.

Personal experience during more than ten years at vocational schools by the first author showed that many students question the usefulness of learning fields like *"business management processes"*. But all trainers regarded the topics of these learning fields as valuable, regardless whether their working processes included it or not, because they all share the view that a deeper understanding of daily working processes would be important for solving most complex problems.

4. DISCUSSION AND CONCLUSIONS

4.1 General Discussion

In our study we asked for typical working processes for IT specialists in the field of IT/CS and how the apprentices can be integrated into these processes. As mentioned above, we were looking for deeper insights and more details of working processes for IT specialists than you might find in general descriptions. Although we summarised these results, we discoverd many new aspects about daily working processes in different industries.

The results revealed that there were some skills which all training companies partaking in the study expected their apprentices to gain:

In the field of IT, the IT specialists for system integration have to be service provider to their colleagues and customers. They need technical skills to install, configure and maintain different IT equipment, but they also need communicative skills, and in several cases the understanding of business processes.

In the field of CS, the IT specialists for application development have to expand on existing or develop new application software. All reported working processes were related to complex business processes. These IT specialists need skills in software project management, modelling and application development. Furthermore they need a deeper understanding of business processes and verbal reasoning to connect all topics.

We further asked for the links between vocational schools and training companies. The answers given covered a wide range of topics.

Documenting work and creating manuals was considered a basic skill for all IT specialists. The trainers criticised that these skills were scarcely part of the lessons. To improve this situation, each learning situation should contain documentation of the work and results as well as presenting it to the other students.

The expectations regarding less teacher-oriented instruction, more open teaching methods and interdisciplinary learning should be easily met, because they are essential parts of the concept of learning fields. When fulfilling these expectations, the teaching methods of the company could better be meshed with the lessons at school and the apprentices would get better opportunities to learn how to deal with new problems.

The trainers related the apprentices' lack of perseverance at working on challenging problems. To improve their abilities, the size and complexity of learning situations should grow during the apprenticeship.

4.2 Correlation between Working Processes and Learning Fields

How can these expectations be put into daily lessons? We tried to compare the learning fields mentioned in the curriculum with the occupational working processes which were related by the trainers. Each learning field is described by several competencies. We took these competencies and compared them with the description of the working processes. So we arrived at a table (see fig. 2), which shows the main objectives of several working processes (as described above) in the first column.

The table headline shows the titles of the different learning fields. Learning fields 1 to 3, 8 and 11 have been taken from the area of business processes and management, the other learning fields originate in the field of IT or CS. The curriculum offers a more detailed description of the learning fields' content, which looks similar to fig. 1.

In the next step we tried to find a correlation between the topics and competencies described in the curriculum and the different working processes. Therefore in each case we used the transcript of the entire interview and compared the description given by the trainers to the competencies defined in several learning fields to decide whether the analysed working process contains skills and competencies from a learning field.

We found that most working processes cover main aspects of different learning fields; which aspect it is also depends on the focus which the companies have. In these cases, we labelled the most likely learning field (according to the trainer's explanation) as *main objective*, the less likely but also suitable ones as *alternate topic*. Many working processes need skills and competencies from additional learning fields. All the different skills have been labelled depending on the students' level of activity.

- ***a***: Students have to gain competencies from the respective learning field to work successfully on the working processes. The students have to deal with the topics actively, e. g. to implement the requirements of a project plan, the students have to learn how to programme or read UML diagrams.
- ***b***: Students have to use previous knowledge from the learning field to deal actively with the problem, so they can practise previous knowledge in different situations. The situation "a new working place" also includes network access of the new computer. Knowledge about IP addresses and skills to configure the computer with these addresses are required skills.
- ***c***: Students actively use previous knowledge for decision making processes, e. g. they have to compare different offers for computers (learning situation mainly from the learning field *simple IT systems*). But the students also need their previous knowledge about calculation and contractual law to decide in favour of an offer or supplier.
- ***d***: Students use previous knowledge implicitly, e. g. knowledge about searching and presenting information or communication skills. These skills are used as a tool in the respective learning situation.

The classification has been made based on the trainers' description; they explained their main focus of the differ-

Learning field - number	1	2	3	4	5	6	7	8	9	10	11
Learning field – name / **Occupational working processes**	*The company and its environment*	*Business processes and operational organization*	*Sources of information and working methods*	*Simple IT systems*	*Professional English for technical occupations*	*Application development and programming*	*Networked IT-Systems*	*Market and customer relationships*	*Public networks and services*	*Maintenance of IT systems*	*Accounting and controlling*
A new working place for an employee	**d**		**d**	**a**	**d**		**b**		**c**		
User help desk	**d**		**b**	**b**	**d**		**c**			**a**	
Installing new software versions		**c**	**d**	**a/b**	**d**		**c**			**a**	
Installation, maintenance and support of servers		**c**	**d**		**b**		**a**			**b**	
Maintenance of telephone systems			**d**		**d**				**a**	**c**	
Installation and configuration of telephone and broadband connection		**d**	**b**		**d**		**a/b**	**b**	**a**		
Installation and support of customer IT solutions, including all hard- and software	**d**	**c**	**b**	**c**	**d**		**a/b**	**b**	**c**	**a**	**c**
Customer advisory service	**b**	**c**	**b**	**c**	**d**		**c**	**a/b**	**b/c**	**c**	
Modelling business processes by using IT infrastructure	**d**	**a**	**d**		**d**	**b/c**	**c**			**b**	**c**
Application development for collection department or accounting department	**d**	**b**	**d**		**d**	**a**					**b**
Planning, documenting and accounting an application development project	**b**		**d**		**d**	**a**					**b**
Implementation of project plans into functional software.	**b**		**d**		**d**	**a**					**b**

Main topic of the respective working process
Alternate topic of the working process

a: **Main learning objective**; apprentice/student has to deal actively with the problem to learn the topics of the learning field
b: Apprentice/student uses mainly previous knowledge from the respective learning field to deal actively with the problem
c: Apprentice/student uses previous knowledge as background for decision making processes
d: Apprentice/student uses the knowledge from the learning field implicitly

Figure 2: Learning fields and occupational working processes

ent working processes and how the apprentices would be involved in them.

In order for teachers to be able to use each working process to develop different learning situations, they can create learning situations which are mainly used for exercising or increasing previous skills and competencies. Most working processes also include working units which can be used to translate previous knowledge into practical skills (classified as "*b*"). Or they can compose learning situations which can be used to gain new competencies described in the respective learning field (labelled as "*a*").

To clearify this approach, the strategy to analyse and classify the working process *"installation, maintenance and support of servers"* will be explained.

The trainers reported very detailed which components, servers and operating systems were used at the company and how the apprentices learned to deal with them. They described their business structure and how it influences the IT-systems of the company. The trainers also explained how the apprentices were promoted to solve more difficult problems, how they were supported by the coworkers and which problems normally occured. Finally, they described which aims should be reached during the training at this department.

Based on these descriptions, the working process contains as main topic (labelled as *"a"* in the table) skills from the learning field *"networked IT-systems"*. The curriculum describes the aims of the learning field: the students should learn to design networked IT-systems, chose components, install and configure hard- and software, put the systems into operation, document their work and the system, present the results and maintain the system. Students should actively learn how to deal with these topics, they should gain action competencies to work independently.

The trainers related that all technical manuals and instructions would be written in English and also many suppliers would only speak English. The aims of the learning field *"professional English for technical occupations"* are described as "the students should know the necessary technical terms for their occupation; they should use this knowledge to document their work and tasks in an appropriate way".

To solve problems concerning the working process the apprentices have to use previous knowledge in English, but they also have the opportunity to improve their skills. Topics of the learning field *"professional English for technical occupations"* are part of the working process, but not the main topic. This aspect results in the label *"b"*.

Another aspect was to decide which soft- or hardware should be used. To make an appropriate decision, the apprentice has to understand for which business processes the

system has to be designed. He has to understand the description of the business process and the process itself. This previous knowledge is described in the learning field "business processes and operational organisation". The apprentices need this knowledge for decision making processes, but neither would they actively deal with it nor had to concentrate on learning about business management (label *"c"*).

The learning field *"sources of information and working methods"* is described as "students can analyse a work order, analyse and use sources of information. They organise their work independently, use working methods and work cooperatively and efficiently. ... The students can appropriately present information. They independently organise their information procurement and continuously update their level of information". The skills described in this learning field should always be implicitly used (label *"d"*); this is also the reason why this is one of the learning fields whose skills were used for all reported working processes.

Implementing learning situations based on these reported working processes would include the main part of the technical issues and many competencies of the curriculum. For this reason taking these processes as a basis for the development of suitable learning situations would cover many technical issues of the curriculum. Figure 2 shows that each learning field at least has one associated working process as main topic.

One of the next steps would be to explore which competencies of the learning fields are covered in detail by the respective working processes, and which ones are missing.

Most working processes require some knowledge of English and skills of working through "*sources of information and working methods*" and "*business processes and operational organisation*". So it seems to be important to involve teachers for English and business processes in developing learning situations.

Due to the situation at school (timetables, spatial situation), each bigger learning situation should be developed in several modules. Each module should contain topics of one learning field. All modules combined build up one learning situation.

Each module of the learning situation can be taught individually, since the class can explore only a number of aspects of the whole process on which the learning situation has been based. An advance organizer could help keeping the students on track, particularly if for the learning situation only a few modules of the working process had been used in class beforehand. Furthermore, an advance organizer could encourage the students to keep the complete working process in mind.

To clarify the idea of *learning situations as modules*, the potential learning situation *"customer advisory service - network expansion"* will be examined. This learning situation consists of several modules. The complexity and detailed teaching content depend on the year of training:

The potential module "analysis of a pre-existing network" could contain network fundamentals like topologies or cable types, but also the understanding of simple IT structures, protocols and network devices.

The module "development of network expansions" would be used to teach network addressing, layer models or complex IT structures in detail. It uses the previous knowledge of the module "analysis of a pre-existing network" for decision-making processes and skills like documenting, search for information or presenting information as tools.

Another module could be "bidding and the conclusion of a contract". Basics of cost calculation or contract law, as well as writing business letters would be part of this element of the process. For this module, skills about networking technologies would be important to evaluate different offers, but are not regarded as a basic skill for understanding contract law.

The last module "network installation and testing" could include configuring and testing network devices or troubleshooting in complex networking structures. This module offers only little new information, but it can be used for exercising and increasing the students' skills.

In all modules, students should learn how to research and interpret information and they should document results and working processes.

To structure learning situations in modules is only one idea given to us while evaluating the information given by the companies. The study provided us with many new or better insights into important working processes and the structure of occupational training of IT specialists, which will be used to develop more teaching material for vocational IT/CS teachers.

5. SUMMARY AND OUTLOOK

The presented interview study is part of a larger project which strives to develop a competence model for selected learning fields, exemplary learning situations and helpful materials and tools for vocational IT/CS teachers.

The main aim of this study was to produce ideas for different learning situations and competencies apprentices should gain during their training. We were presented with several suitable working processes which could lead to various learning situations. Another result of the study is the confirmation that vocational IT/CS teachers seem to usually teach the right things, in particular concerning technical topics. So we have to train the teachers to teach the right things in the right way; the right way being the implementation of the concept of learning fields, which allows and demands of the teachers to use methods of contextual teaching. The interviews gave us deep insights into training at the companies, not only into the working processes, but also into training schedules and the companies' problems and requirements.

There were also some good ideas for learning situations given to us by teachers [19]. Currently, we are developing some exemplary learning situations and related teaching material by using the teachers' and trainers' ideas and information. Simultaneously, we are working on the development of a competence model and evaluate guidelines and criteria for appropriate learning situations to support teachers in leading the concept of learning fields to a success.

6. REFERENCES

[1] R. Bader. Das Lernfeld-Konzept in den Rahmenlehrplänen (in German). *Die berufsbildende Schule*, 50(7–8):211–213, 1998.

[2] H. Beek, P. Binstadt, E. Hertle, H. Kremer, F. Sloane, and A. Zöller. *Modellversuch NELE: Neue Unterrichtsstrukturen und Lernkonzepte durch berufliches Lernen in Lernfeldern: Abschlussbericht (in German)*. Staatsinstitut für Schulpädagogik und Bildungsforschung, München, 2003.

[3] L. Chen, S. Ma, L. Shi, G. Li, L. Zhang, and L. Zheng. *The construction of the secondary vocational teachers training system based on 'cooperation between school and enterprise'*, volume 135 of *Advances in Intelligent and Soft Computing*. 2012.

[4] T. Deissinger and S. Hellwig. Apprenticeships in germany: modernising the dual system. *Education + Training*, 47(4/5):312–324, 2005.

[5] M. Fischer and W. Bauer. Competing approaches towards work process orientation in German curriculum development. *European journal of vocational training*, 40(2007/1):140–157, 2007.

[6] U. Fuller, J. C. Little, B. Keim, C. Riedesel, D. Fitch, and S. White. Perspectives on developing and assessing professional values in computing. *ACM SIGCSE Bulletin*, 41(4):174, Jan. 2010.

[7] A. Gramm, M. Hornung, and H. Witten. Email for you (only?). page 116. ACM Press, 2012.

[8] J. K. Huggins. Engaging computer science students through cooperative education. *ACM SIGCSE Bulletin*, 41(4):90, Jan. 2010.

[9] C. Iannelli and D. Raffe. Vocational upper-secondary education and the transition from school. *European Sociological Review*, 23(1):49–63, Dec. 2006.

[10] W. Jianwei, B. Hongjie, and Y. Guoxin. *Exploration and analysis of teaching methods of higher vocational education curricula*, volume 108 of *Advances in Intelligent and Soft Computing*. 2011.

[11] L. Jingfu and L. Zhijun. Exploration and analysis of curriculum teaching reform based on the work process. In Y. Wu, editor, *Advanced Technology in Teaching - Proceedings of the 2009 3rd International Conference on Teaching and Computational Science (WTCS 2009)*, volume 116 of *Advances in Intelligent and Soft Computing*, pages 7–12. Springer Berlin / Heidelberg, 2012.

[12] J. Klusmeyer. 15 Jahre Lernfeldkonzept: Implementation geglückt? (in German). *Berufsbildung – Zeitung für Praxis und Theorie in Betrieb und Schule*, 113:15–17, 2012.

[13] M. Knobelsdorf and R. Romeike. Creativity as a pathway to computer science. *ACM SIGCSE Bulletin*, 40(3):286, Aug. 2008.

[14] Y. B.-D. Kolikant and M. Ben-Ari. Fertile zones of cultural encounter in computer science education. *Journal of the Learning Sciences*, 17(1):1–32, Feb. 2008.

[15] J. Koubek, C. Schulte, P. Schulze, and H. Witten. Informatik im Kontext. ein integratives Unterrichtskonzept für den Informatikunterricht (in German). In B. Körber, editor, *Proceedings of the 2009 German conference on Informatics and Schools (INFOS 2009)*, pages 268–279, Bonn, 2009. Köllen.

[16] P. Mayring. *Qualitative Inhaltsanalyse. Grundlagen und Techniken (in German)*. Deutscher Studien Verlag, Weinheim, 7 edition, 2000.

[17] L. Ni. What makes CS teachers change? *ACM SIGCSE Bulletin*, 41(1):544, Mar. 2009.

[18] S. Opel and T. Brinda. Learning Fields in Vocational IT Education – Why Teachers Refrain From Taking an Opportunity. In M. Knobelsdorf and R. Romeike, editors, *Proceedings of 7th Workshop in Primary and Secondary Computing Education (WiPSCE 2012)*, pages 155–156. ACM Press, 2012.

[19] S. Opel and T. Brinda. Learning Fields in Vocational IT Education – How Teachers Interpret the Concept. In I. Diethelm and R. T. Mittermeir, editors, *ISSEP 2013, LNCS 7780)*, pages 147–158, Heidelberg, 2013. Springer.

[20] M. Pilz. Initial vocational training from a company perspective: a comparison of british and german in-house training cultures. *Vocations and Learning*, 2(1):57–74, Dec. 2008.

[21] P. Ryan. Evaluating vocationalism*. *European Journal of Education*, 38(2):147–162, June 2003.

[22] P. Ryan. Apprenticeship: between theory and practice, school and workplace. Economics of Education Working Paper Series 0064, University of Zurich, Institute for Strategy and Business Economics (ISU), 2011.

[23] M. Salama and T. Thabet. A curricular reform proposal for egyptian computer engineering education ECEE. In *2010 IEEE Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments*, 2010.

[24] S. Shooter and M. Mcneill. Interdisciplinary collaborative learning in mechatronics at bucknell university. *Journal of Engineering Education*, 91(3):339–344, 2002.

[25] Staatsinstitut für Schulqualität und Bildungsforschung. Lehrplanrichtlinie für die Berufsschule. Fachklassen: Fachinformatiker/Fachinformatikerin (in German). München, 2007.

[26] H. Witten and M. Hornung. Chatbots Teil 1 (in German). *Log In*, 154/155:51–60, 2008.

[27] H. Witten and M. Hornung. Chatbots Teil 2 (in German). *Log In*, 157/158:63–74, 2009.